O Level Pure Physics Structured

Electromagnetic Induction Test 4.0

Q1

Fig 11.3 shows an electric dynamo which generates Alternating Current (A.C.) to power up the bicycle lamp when it is moving.

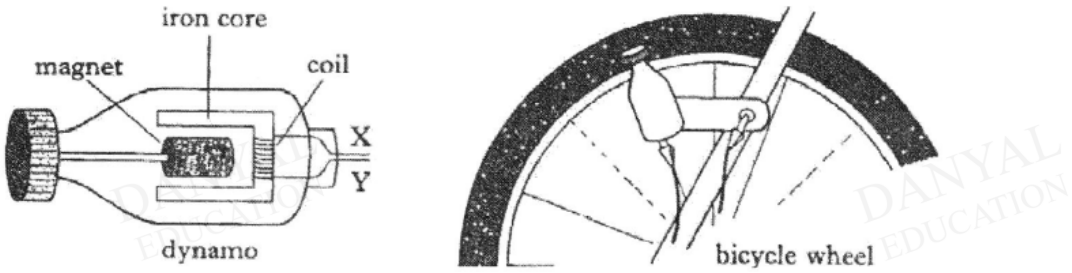


Fig. 11.3

(a) Describe two advantages of rotating the magnet instead of rotating the coil.

.....

..... [2]

(b) State how the current through **X** and **Y** will be affected when

(i) the soft iron bar is replaced by a plastic bar.

.....

.....

..... [2]

(ii) the number of turns in the coil in increased.

.....

.....

..... [2]

(iii) the cyclist cycle faster.

.....

.....

..... [2]

(c) Suggest and explain how you would modify the circuit so that a direct current is produced.

.....

..... [2]

Q2

A spring hangs vertically from a fixed point. A copper plate is attached to the free end of the spring, as shown in **Fig. 12.1**.

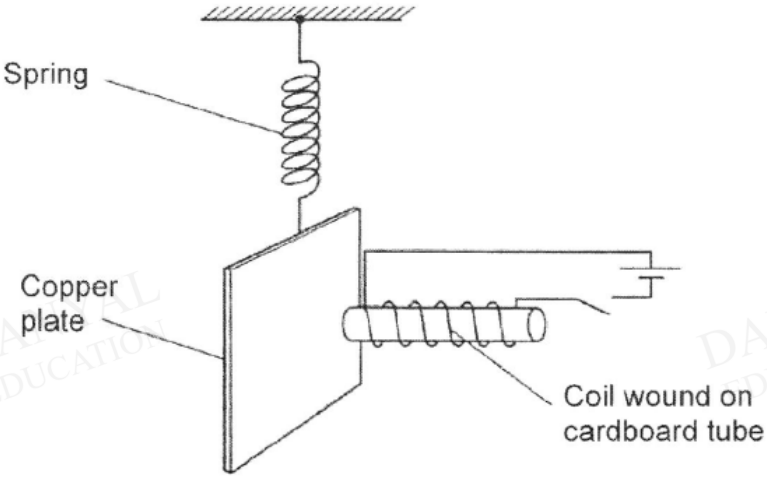


Fig. 12.1

One end of a coil of wire, wound on a cardboard tube, is placed near to the copper plate.

The copper plate is displaced vertically and then released. The variation with time *t* of the vertical displacement *y* of the plate is shown in **Fig. 12.2**.

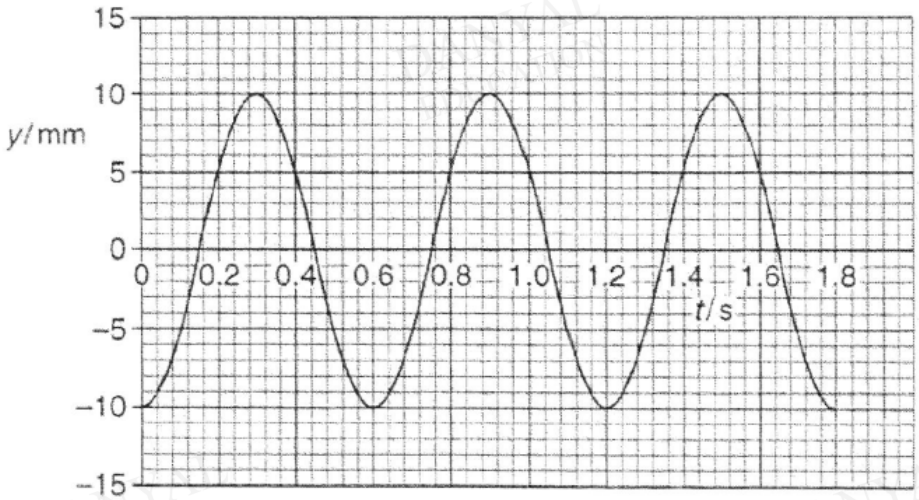


Fig. 12.2

(a) Calculate the frequency of the oscillation.

Frequency of oscillation = ... [2]

(b) Write down the amplitude of the oscillation.

..... [1]

(c) At time t = 1.8 s, the current in the coil in **Fig. 12.1** is switched on. The variation with time t of the subsequent oscillations of the plate is shown in **Fig. 12.3**.

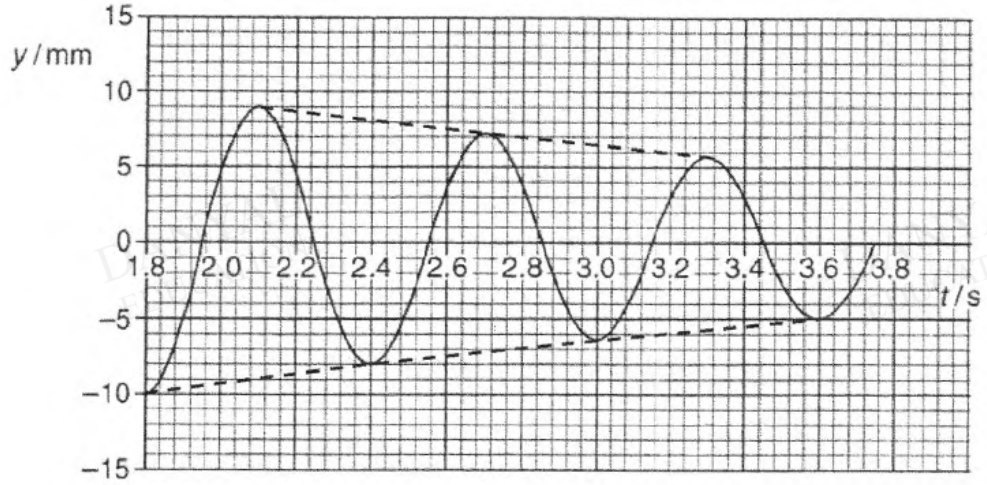


Fig. 12.3

(i) Explain why the amplitude of the oscillations is lower after the coil is switched on.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(ii) It is observed that the amplitude of the oscillations decreases with a decreasing rate. Explain.

.....

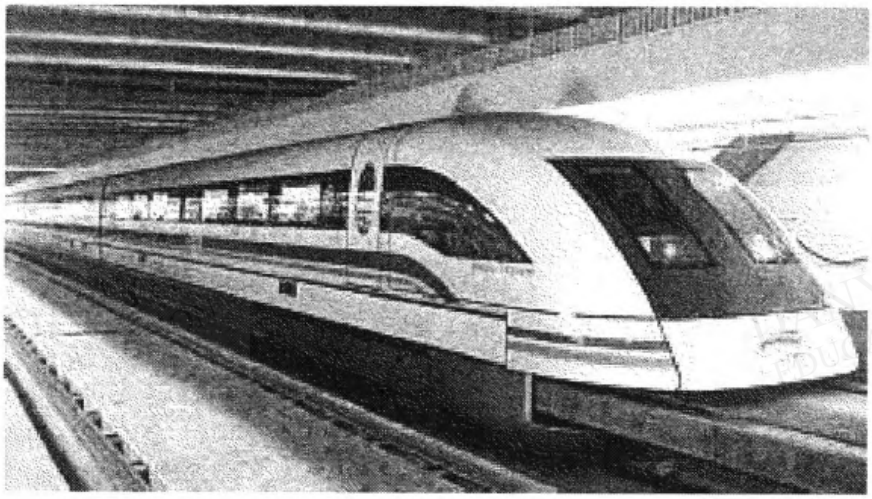
.....

.....

..... [2]

Q3

A Maglev or magnetically levitated train, shown in the figure below, uses magnetism to hover above the ground thus allowing it to travel faster than a regular train.



Maglev train uses superconducting electromagnets which are cooled to extremely cold temperature so they can conduct electricity with zero resistance. The magnets are placed at the bottom of the train. As the train moves, current is induced in the wire coils placed in the guideway or train tracks. The magnetic force between the magnets and the induced currents lifts the train. A medium-sized MagLev has a mass of 30 000 kg. With an energy consumption of 1.7 kW per tonne, the train is able to travel at 500 km/h.

a. Using the principles of electromagnetic induction, explain how the magnetic force between the magnets and the induced currents can be used to lift the train.

[2]

b. Convert 500 km/h to m/s.

[1]

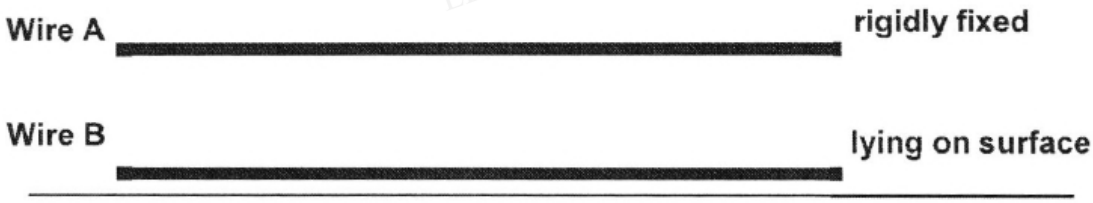
c. Suggest a reason why MagLev is able to travel at such a speed.

[1]

d. The distance from Pudong Airport in Shanghai to Shanghai city is 30 km. What is the energy consumption, in joules, of a medium-sized MagLev travelling from the airport to the city in a single-trip if it travels at 500 km/h throughout the journey?

[3]

e. A similar levitation system, which is shown in the figure below, has are two horizontal wires A and B of the same length. Wire A is rigidly fixed a distance 5 mm vertically above wire B. Wire B lies on a surface with light flexible connecting wires attached to it.



A fixed current flows in wire A. The current in wire B is gradually increased until B just starts to lift off the surface.

i. Explain why wire B lift off the surface as current in the wire is gradually increased.

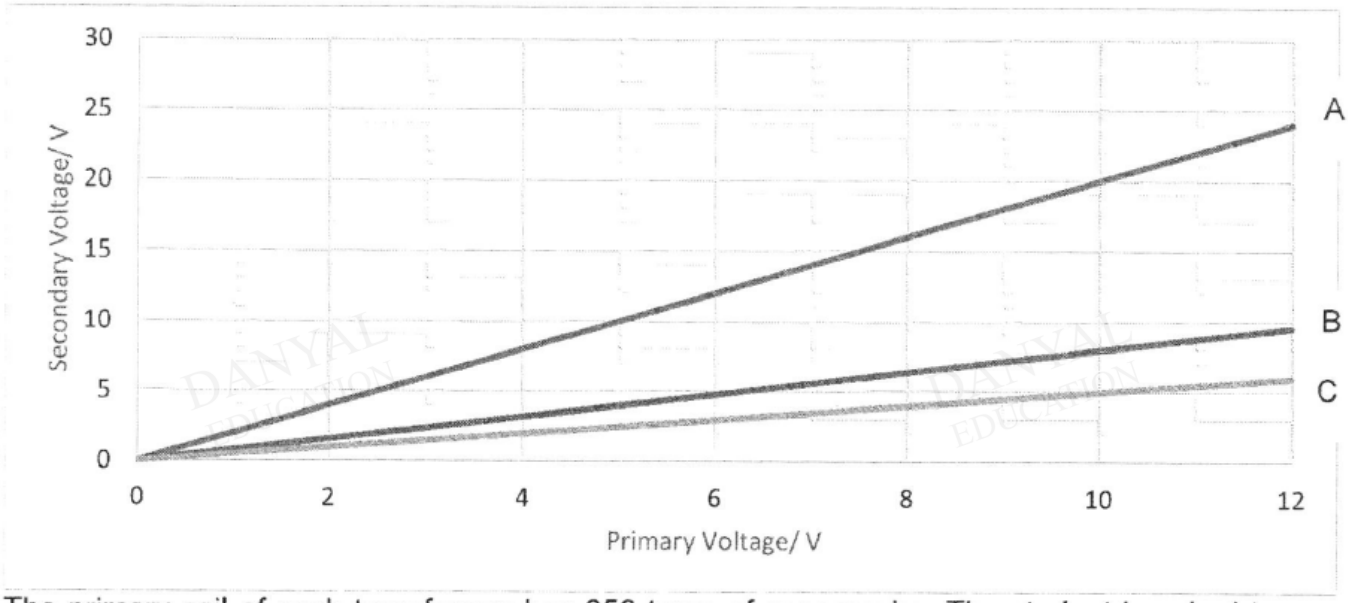
[2]

ii. For wire B to experience a lift, in which direction should the currents in A and B be flowing?

[1]

Q4

A student is given 3 transformers labeled A, B and C.



The primary coil of each transformer has 250 turns of copper wire. The student is asked to investigate the relationship between the primary voltage V_1 and secondary voltage V_2 of each transformer.

The student applies various input voltages V_1 to the primary coil and measures the output voltages V_2 from the secondary coil of each transformer.

The results of his investigations are shown in the graph below.

a. Based on the graph shown,

i. state the relationship between V_2 and V_1.

[1]

_____

_____

ii. indicate with a tick, the type of transformer for each case in the table below.

[1]

Transformer	Step-Up Transformer	Step-Down Transformer
A		
B		
C		

iii. Assuming that all the transformers are 100% efficient, fill in the missing results in the table below.

[3]

Transformer	Primary voltage, V_1/V	Secondary voltage, V_2/V	Number of primary turns	Number of secondary turns
A	12		250	
B	6		250	
C		4	250	

b. Explain the working principle of a transformer.

[2]

c. The efficiency of transformer A is given as:

Efficiency = 0.39 m x 100%

where m = gradient of graph A.

Calculate the efficiency of transformer A.

[2]

d. Suggest a reason why the efficiency of a transformer is less than 100%.

[1]

Q5

Fig. 7.1 shows a workman using a cordless electric drill.

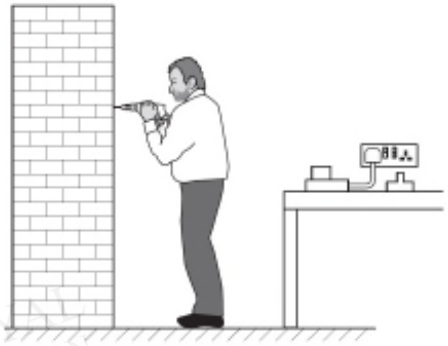


Fig. 7.1

The motor of the drill is powered by a rechargeable battery with an electromotive force (e.m.f.) of 18 V. When the drill is used, the current supplied to the motor is 25 A.

(a) **(i)** Explain what is meant by an *e.m.f. of 18 V*.

_____

_____ [1]

(ii) Calculate the power supplied to the motor.

power = _____ [1]

(b) After 90 minutes of use, the battery is flat. It is connected to a charger and is recharged.
The charger includes a transformer that produces a 23 V alternating current (a.c.) output from a 230 V a.c. mains supply.

(i) Draw a labelled diagram to show the structure of the transformer used in the charger.

[2]

(ii) State how the transformer ensures that the a.c. output has a value of 23 V when the input is the 230 V a.c. mains supply.

_____ [1]

(iii) State and explain **one** advantage of using an alternating current for long-distance transmission of electrical power.

_____

_____

_____ [2]

Answers

Electromagnetic Induction Test 4.0

Q1

a	Less wear and tear in wires No need for the use of slip rings	B1 B1
bi	Amplitude will be lesser Frequency the same	B1 B1
bii	Amplitude will be greater Frequency the same	B1 B1
biii	Amplitude will be greater Frequency will be greater	B1 B1
c	Add a diode at X/ split ring Diode will prevent current from flowing from the other direction	B1 B1

Q2

a	$f = \frac{3}{1.8} \approx 1.7$ Hz (2 or 3 s.f)	Working [1] Ans [1]
b	10 mm	[1]
ci	A **magnetic field is created around the coil** as the coil is switched on. **[1]** As the **copper plate, an electrical conductor, oscillates, it cuts the magnetic field of the coil. [1]** According **to Faraday's law of electromagnetic induction, an induced e.m.f will be created across the copper plate, thus creating induced eddy in the copper plate. [1]** According to **Lenz's law, the induced eddy current will created a magnetic field to oppose the change producing itself.[1]** **This will create a resistive force that will dampen the oscillation of the copper plate**, thereby reducing the amplitude of oscillations. **[1]**	[5]
cii	As the amplitude decreases, **the copper plate will cut the magnetic field of the coil at a lower rate. [1]** This will result in **a lower resistive force created to dampen the oscillation. [1]**	[2]

Q3

a. Using the principles of electromagnetic induction, explain how the magnetic force between the magnets and the induced currents lifts the train.

[2]

Superconducting electromagnets produces magnetic field which changes as the train moves. A1
This changing the magnetic field links with the coils on tracks where there is induced current. By Lenz law, the direction of induced current always opposed the change the produces it, so the train and the track repel. A1

b. Convert 500 km/h to m/s.

[1]

500 km/h = 139 m/s A1

c. Suggest a reason why MagLev can travel at such speed.

[1]

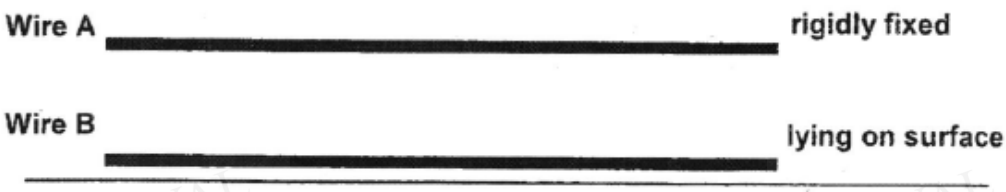
no friction as train is levitated A1

d. The distance from Pudong Airport in Shanghai to Shanghai city is 30 km. What is the energy consumption, in joules, of a medium-sized MagLev travelling from the airport to the city in a single-trip if it travels at 500 km/h throughout the journey?

[3]

Energy consumption for train per sec = 1.7 kW x 30 = 5.1 kW A1
Time of travel = 30 / 500 = 0.06 h = 216 s A1
Total energy consumption = 5100 x 216 = 1101600 J = 1.10 x 10^6 J A1

e. A similar levitation system, which is shown in the figure below, has are two horizontal wires A and B of the same length. Wire A is rigidly fixed a distance 5 mm vertically above wire B. Wire B lies on a surface with light flexible connecting wires attached to it.



A fixed current flows in wire A. The current in wire B is gradually increased until B just starts to lift off the surface.

i. Explain why wire B lift off the surface as current in the wire is gradually increased.

[2]

parallel current-carrying wire exert attractive force between them, A1
As the current increases, the force increases until it is more than the weight of the wire A1

ii. For wire B to experience a lift, in which direction should the currents in A and B be flowing?

[1]

Same direction A1

Q4

a. Based on the graph shown,

i. state the relationship between V_2 and V_1.

[1]

secondary voltage, V2 is directly proportional to the primary voltage, V1 A1

ii. indicate, with a tick, the type of transformer for each case in the table below.

[1]

Transformer	Step-Up Transformer	Step-Down Transformer
A	√	
B		√
C		√

iii. Assuming that all the transformers are 100% efficient, fill in the missing results in the table below.

[3]

Transformer	Primary voltage, V_1/V	Secondary voltage, V_2/V	Number of primary turns	Number of secondary turns
A	12	**24**	250	**500**
B	6	**4.8**	250	**200**
C	**8**	4	250	**125**

b. Explain the working principle of a transformer.

[2]

An alternating current supply is provided to the primary coil A1
As the current changes direction, this will change the magnetic field.
According to Faraday's Law, an induced emf will be created in the secondary coil. A1
The magnetic core will provide the link between the primary and the secondary coil

c. The efficiency of transformer A is given as:

Efficiency = 0.39 m x 100%

where m = gradient of graph A.

Calculate the efficiency of transformer A.

[2]

m = 20/10 = 2 (derived from graph) A1
Efficiency = 0.39 (2) x 100% = 78% A1

d. Suggest a reason why the efficiency of a transformer is less than 100%.

[1]

Power loss due to heat loss bec of resistance of the coils
OR
Power loss due to leakage of magnetic field lines between the pri and sec coils
OR
Power loss due to heat loss bec of eddy currents induced in the soft iron core
OR A1
Power loss due to hysteresis loss caused by the flipping of magnetic dipoles in the iron core due to a.c. (i.e. magnetizing and demagnetizing of the soft iron core)

Q5

(a)	**(i)**	18 J of work is done to drive a unit charge around the circuit.	[1]
	(ii)	P = IV = 25 x 18 = 450 W	[1]
(b)	**(i)**	A transformer with the following labels: laminated (soft) iron core; primary coil connected to a 230 V a.c. supply and the secondary coil connected to a 23 V a.c. output. There should be more turns in the primary coil.	[1] [1]
	(ii)	The ratio of the primary to secondary coil of the transformer is maintained at 10:1.	[1]
	(iii)	An alternating current allows voltage to be stepped up with the use of a transformer. This lowers the transmission current and hence reduces energy loss due to Joule heating.	[1] [1]